First Great Western

# READING TURBO MAINTENANCE DEPOT

## CLASS 165/166 TURBO

## HYDROSTATIC/SERCK SYSTEM

First
165 103

# Introduction

Almost all hydraulic systems comprise of a reservoir to store the fluid, a pump to force the fluid around the circuit, control valves to direct the flow of fluid and normally a ram or motor to provide lateral or rotary motion.

There are up to three motors in the hydrostatic system of the Class 165/166 DMMU. One drives the radiator fan, another drives the alternator and on the Class 166 one motor drives the air conditioning compressor.

All the hydrostatic circuits are contolled by an electronic unit which in turn controls a hydrostatic valve.

Remember - Safety First

This is an uncontrolled document
and is for training purposes only.

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# CLASS 165

## Introduction

The function of the vehicle hydrostatic system is to provide a drive to the alternator and coolant radiator fan. This is achieved by circulating hydraulic fluid through two closed loop circuits which incorporate the drive motors to these units. Although each of these units operates independently, it follows that if the engine is not running the associated systems will be non-operational.

There are two hydraulic circuits which share a common reservoir. One circuit comprises the variable displacement pump which drives the alternator. The other circuit consists of the engine mounted pump and the fan motor for the cooler group.

The alternator and coolant radiator fan are functionally independent and are controlled by the respective controls which form part of those systems.

The function of the radiator drive system is to allow the engine coolant to reach its working temperature range as quickly as possible and then to maintain the coolant temperature within its working range. This is done by operating and controlling the motor and hence the fan which provides a cooling air flow through the cooling system radiator.

## System Function

### Hydrostatic system drives

The system comprises two separate drives to component items; alternator, and radiator fan.

A variable displacement pump driven from the diesel engine crankshaft via a driveshaft supplies hydraulic fluid to the alternator drive motor. A separate pump supplies fluid to the radiator fan motor. Each motor is individually controlled in respect of the equipment served.

The system is supplied with fluid from a common reservoir via interconnecting pipework to the drive components. From the pumps it is delivered under pressure to the drive motors which operate in proportion to need; as determined by the controllers associated with the respective equipment, the fluid being by-passed if there is no duty requirement. After serving the motors, in run or by-pass mode, the fluid is returned via an oil cooler and filter to the oil reservoir.

Each pump and motor is fitted with a leakage connection from where the fluid which leaks past the piston and control valves is returned, via a fine filter to the reservoir. This leakage oil serves two functions: as lubrication of the working parts of these items: as a wear indicator if excessive amounts are returned.

All pumps and motors operate on a similar principle, converting rotary motion into pressure, or pressure into rotary motion through a rotary piston group which forms the basis of each unit. The variable displacement pump is fitted with a control plate and lens by which the output is carried. The fan pump has a constant output. Both outputs are proportional to engine speed. Variable displacement pump is flow controlled to make its output independent of engine speed above 870 rpm.

Each motor is fitted with a solenoid control valve which opens a by-pass valve in proportion to requirement. This is determined by locally mounted controllers and relays/ thermostats/sensors as applicable to unit which provides the necessary electrical input to the solenoid valve.

### Radiator fan drive

#### a. Coolant temperature below 87°C

With the engine running, the fan pump output pressure is delivered to the fan motor and returns via the oil cooler return line back to the reservoir.

As the coolant temperature will not be high enough to operate the fan motor controller temperature sensor and hence control value, the fan motor return line will be fully open and the fan motor will not rotate.

#### b. Coolant temperature in the range 87 to 93°C

As the temperature rises above 87°C the fan controller will sense the increase and start to shut off the return line to the reservoir, via a solenoid valve mounted on the motor body. As the fan controller progressively closes the fan motor return, the fan motor inlet fluid pressure to the motor cylinders increases at the same rate.

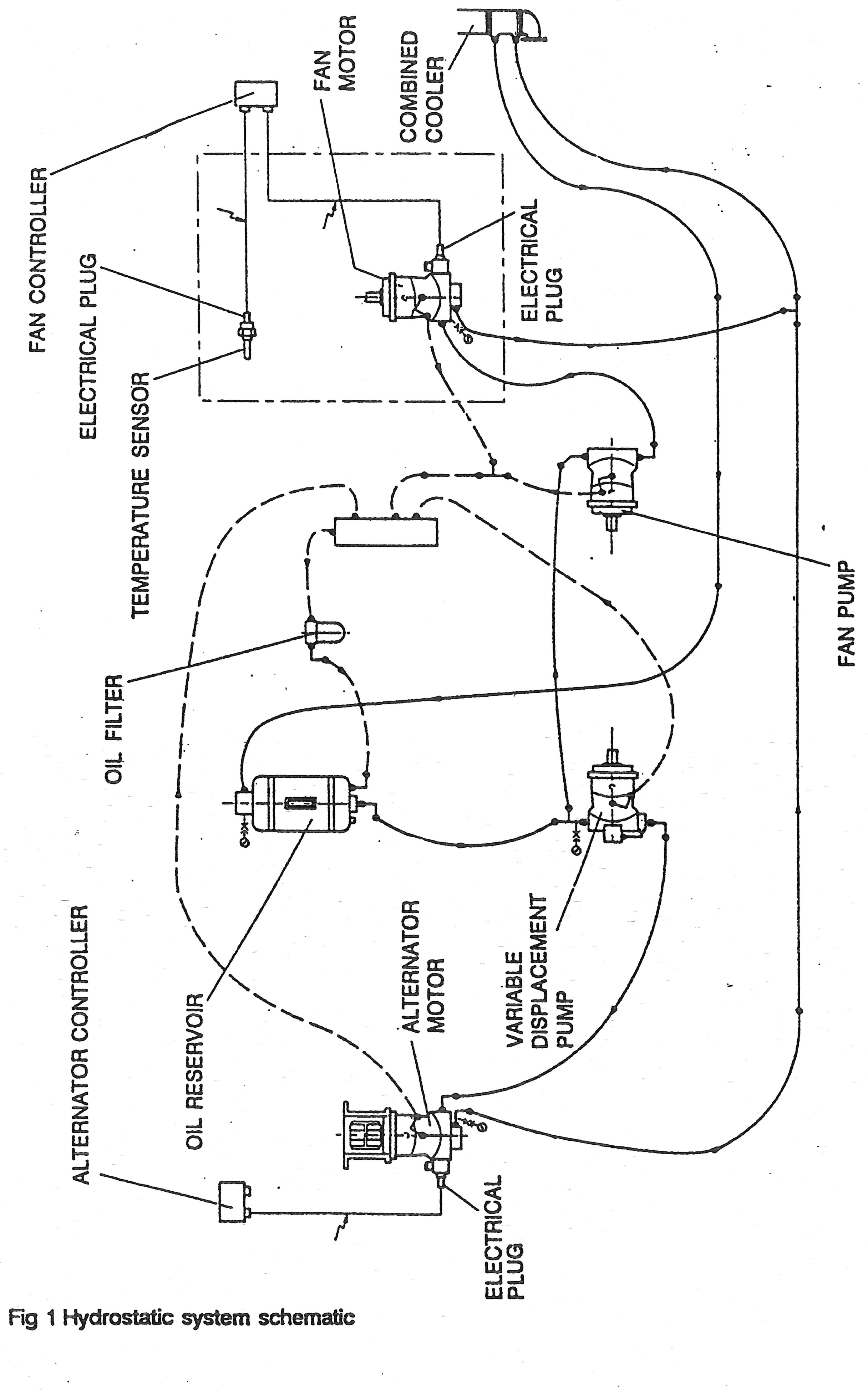

FAN CONTROLLER
ELECTRICAL PLUG
TEMPERATURE SENSOR
FAN MOTOR
COMBINED COOLER
ELECTRICAL PLUG
OIL FILTER
FAN PUMP
ALTERNATOR CONTROLLER
OIL RESERVOIR
ALTERNATOR MOTOR
VARIABLE DISPLACEMENT PUMP
ELECTRICAL PLUG

Fig 1 Hydrostatic system schematic

As the fluid pressure increase, the motor and fan will turn to draw cooling air through the radiator, until at maximum temperature the pressure runs the motor at full speed. The cooling air flow will increase the dissipation of heat from the radiator and so lower the coolant temperature, causing the fan controller to open the solenoid valve and return line, reducing the fan motor output and speed in proportion. This sequence will occur whenever the system temperature changes.

In this manner the coolant temperature is maintained within its efficient range while the fan speed varies to match the cooling load required by the engine and transmission.

Note : The temperatures are nominal. The temperature at which the fan control bypass valve is fully closed has a tolerance (93°C + 1°C) and fan motor speed is maximum at this setting in relation to the engine speed.

### c. Coolant temperature above 93°C

The fan motor control valve, operated by the solenoid via the temperature sensor and controller, is fully closed at this setting and full fan motor speed is achieved. This speed varied directly with the engine speed.

### Alternator drive

With the engine running, the fluid from the variable displacement pump is circulated to the alternator motor. The fluid then returns to the oil reservoir after first passing through the hydraulic oil cooler. The controller allows the motor to ramp up the alternator to achieve a proportional speed with the engine (below 870rpm).Up to 870rpm the alternator speed depends solely on engine speed.

The vehicle start circuit has a preset time delay for generator start; this ensures that the alternator does not start up simultaneously with the engine. The delay is achieved by a time relay which opens the controller electrical circuit for a 30 sec period during the start phase and repeat starts of the diesel engine. A further 10 sec delay is incorporated in the control when the time relay closes; the generator speed increases from zero to maximum during this period. This is to ensure that there are no pressure surges in the hydraulic system.

Delayed starting of the motors prevents pressure peaks in the hydraulic circuit

## System Components

### Variable displacement pump (Fig 2)

The pump is designed to rotate in one direction only. The drive shaft is located by two tapered roller bearing in the pump housing. Attached to the drive shaft are seven pistons, arranged in a circle, these rotate the cylinder to activate the pump.

The cylinder moves on a spherical control lens (see Fig 2) which is provided with kidney-shaped control slots. The control lens can be moved on a circular pathway in the connection plate, with oil channels leading to the high and low pressure connections. The cylinder is retained in position by the central pin and is held against the surface of the control lens in a pressureless condition by cup springs.

When the pressure increases, the cylinder block is balanced by hydraulic forces such that a film of oil is always present between the cylinder block and the spherical control lens. The pin is lubricated by leakage oil via the bores in the drive shaft. Even at high pressures the amount of leakage oil is low.

The pump pistons lie at an angle to the drive shaft axis. When the drive shaft rotates, the cylinder block and piston assemblies turn and the pistons reciprocate within their cylinders to an extend determined by the angle of swivel on the control lens. As each piston travels from the bottom to the top of the pump, the volume of its cylinder increases and the resulting depression draws hydraulic oil into the cylinder.

They cycle is completed by the piston travelling from top to bottom of the pump. This action decreases the cylinder volume, which pressurises and expels the hydraulic oil. The oil flow rate is dependent on the drive speed and angle of swivel of the cylinder. Adjustment of the cylinder angle is achieved by a piston in the connection block.

An adjustment pin penetrates through the control lens and is fixed to the adjusting piston. A change in the angle of swivel and hence adjustment of flow rate between Q max and Q min can be achieved by displacement of the control piston which is actuated by oil pressure on the piston faces.

A small quantity of control oil is routed from the pressure side to the small surface of the control piston via internal bores (self controlling), the oil is also routed via the cover and connection plate to the control piston. When the control function is activated, the position of the piston alters and allows control oil to flow to the adjusting piston (large surface) and adjustment of the pump occurs. Otherwise the load on the adjusting piston surface is removed and the pump returns to its original position.

The variable displacement pump is controlled to give a constant flow so that for most of the engine speed range the alternator runs at constant speed, independent of engine speed. At approximately 870 rpm the pump reaches maximum swash, so as the engine speed falls further, the alternator runs correspondingly slower.

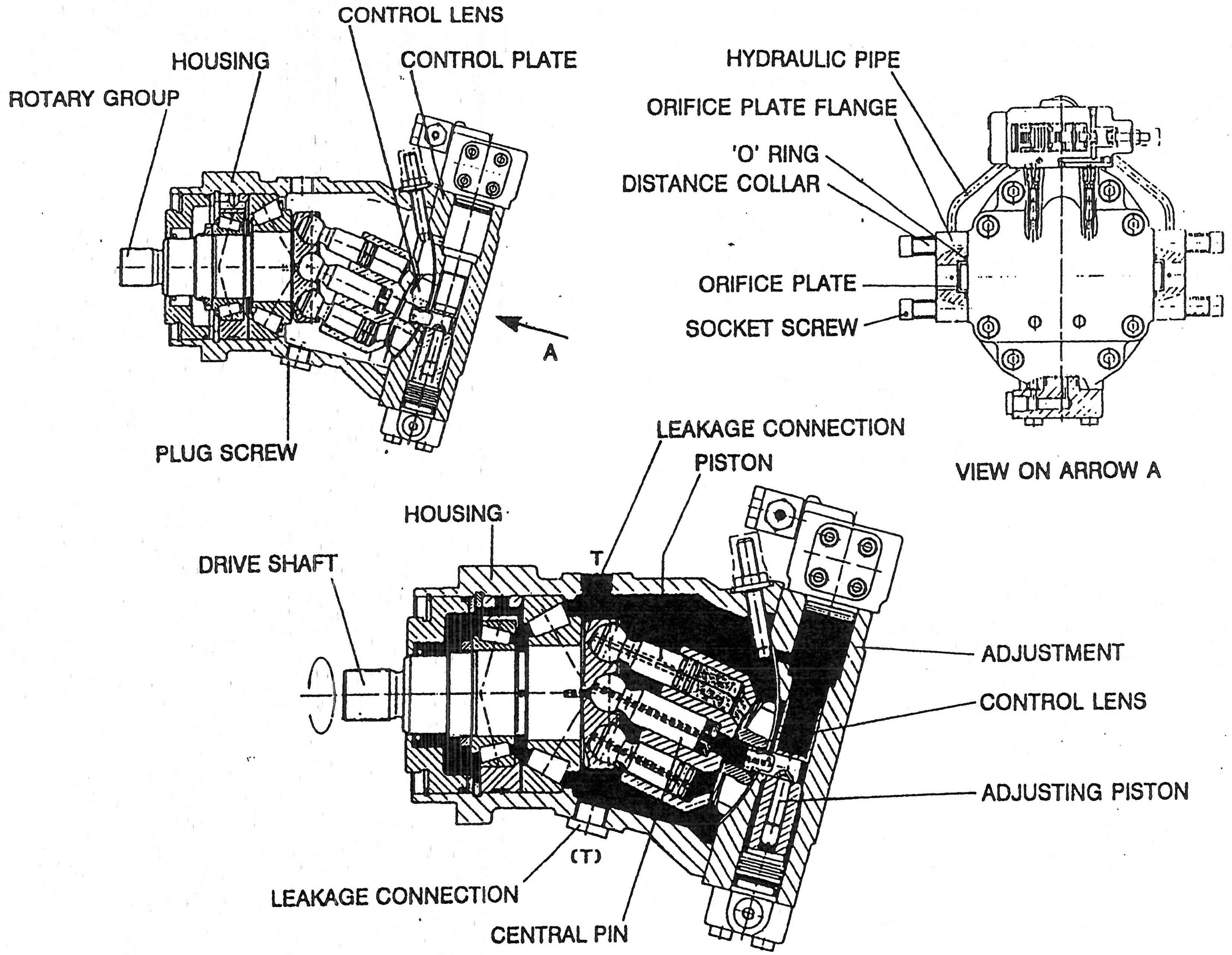

CONTROL LENS
HOUSING
CONTROL PLATE
ROTARY GROUP
A
PLUG SCREW
HYDRAULIC PIPE
ORIFICE PLATE FLANGE
'O' RING
DISTANCE COLLAR
ORIFICE PLATE
SOCKET SCREW
VIEW ON ARROW A
LEAKAGE CONNECTION
PISTON
HOUSING
T
DRIVE SHAFT
ADJUSTMENT
CONTROL LENS
ADJUSTING PISTON
(T)
LEAKAGE CONNECTION
CENTRAL PIN

Fig 2 Variable displacement pump

### Fan pump (Fig 3)

The pump pistons lie at an angle of 40° to the drive shaft axis. As the drive shaft rotates, the cylinder block and piston assemblies turn. This causes the pistons to reciprocate within their cylinders. As each piston travels from the bottom to the top of the pump, the volume of its cylinder increases. The resulting depression draws hydraulic oil into the cylinder.

The cycle is completed by the piston travelling from top to bottom of the pump. This action progressively decreases the cylinder volume, which pressurises and expels the hydraulic oil.

During starting and idling the cylinder block is held against the spherical control plate by a spring beneath the central pin. When the pressure increase, the cylinder block is balanced by hydraulic forces such that a film of oil is always present between the cylinder block and the spherical control plate.

Pump operation is continuous. At any instant three to three and a half cylinders are delivering pressure oil through the kidney shaped outlet port; the remainder are accepting oil through a similar shaped inlet port. A further oil line on the pump returns leakage oil used for pump lubrication to a connection on the bottom of the reservoir, via a fine filter.

### Fan motor (Fig 4)

The fan motor pistons and cylinder lie at an angle of 40° to the driven shaft. The internal components of the motor are identical to the engine driven pump, with the exception that a control valve is fitted, (refer to Fig 5). Otherwise the motor operates in a similar way to the pump; expect the process is reversed and pressure is converted to rotary motion.

Hydraulic oil under pressure enters through the inlet port into the cylinder with the smallest volume. Pressurised oil forces the piston outwards which turns the driven shaft. As the driven shaft rotates, the cylinder volume increases until the piston reaches top dead centre. As each piston travels from top to bottom, the cylinder volume decreases, discharging hydraulic oil from the outlet until it reaches bottom dead centre, when it has completed one stroke.

Operation is continuous, proving a supply of oil is available to the cylinders. At any one moment three to three and one half cylinder bores are open adjacent to the kidney shaped slot (pressure side). The remaining cylinder bores are open to the return slot which can be open or closed, depending on the position of the bypass control valve slide. This is actuated by a solenoid valve, and controls motor speed from zero to maximum, following input from the controller.

### Motor controls

The Serck Behr control system consists of the following main components:
Motor, main control valve (slide valve), solenoid operated control valve, controller and temperature sensor, or relay to activate the system.

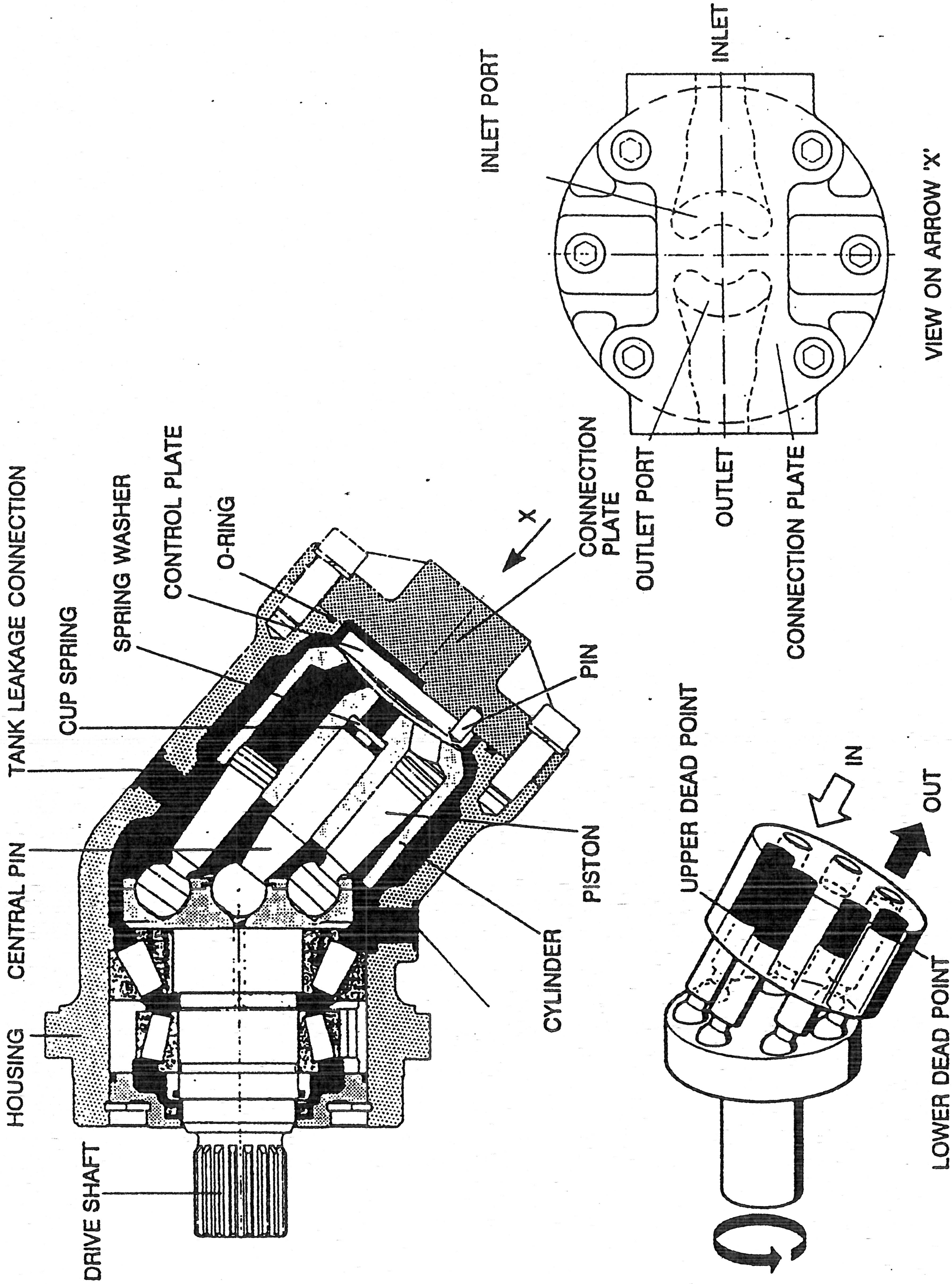

DRIVE SHAFT
HOUSING
CENTRAL PIN
TANK LEAKAGE CONNECTION
CUP SPRING
SPRING WASHER
CONTROL PLATE
O-RING
X
CONNECTION PLATE
PIN
PISTON
CYLINDER
UPPER DEAD POINT
IN
OUT
LOWER DEAD POINT
INLET PORT
OUTLET PORT
OUTLET
CONNECTION PLATE
INLET
VIEW ON ARROW 'X'

Fig 3 Fan pump assembly

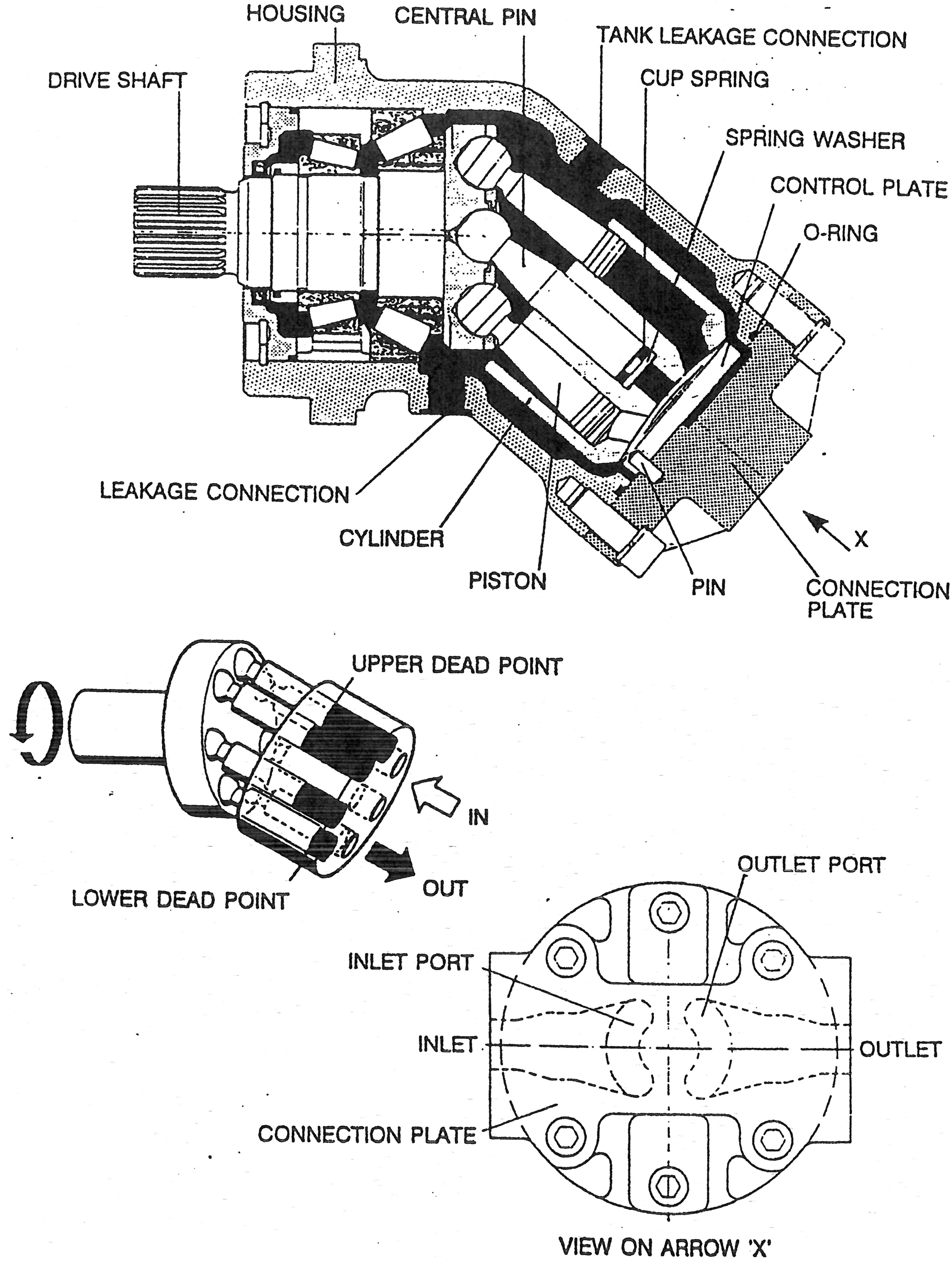

HOUSING
CENTRAL PIN
TANK LEAKAGE CONNECTION
DRIVE SHAFT
CUP SPRING
SPRING WASHER
CONTROL PLATE
O-RING
LEAKAGE CONNECTION
CYLINDER
PISTON
PIN
X
CONNECTION PLATE
UPPER DEAD POINT
IN
OUT
LOWER DEAD POINT
OUTLET PORT
INLET PORT
INLET
OUTLET
CONNECTION PLATE
VIEW ON ARROW 'X'

Fig 4 Fan motor

**Motor control valve (Fig 5)**

The control valve is a directly controlled pressure limiting valve fitted to the motor body. The operation is similar for both radiator and alternator motors.

The main control valve (slide valve) is located in the connection plate of the motor. When actuated, it opens or shuts the bypass port on the motor. A solenoid valve actuates the main control slide valve; this is attached directly to the side of the connection plate.

The solenoid valve is connected electrically to the motor controller. The electrical input current from the motor controller causes a proportional increase of the solenoid magnetic force which acts upon the compression spring via a ball on the valve cone.

At minimum input current the magnetic force is practically zero, the valve therefore remains closed, closing the bypass to the pre-set maximum pressure valve. In this situation the motor rotates at maximum speed.

At maximum input current the magnetic force rises to a maximum value, the valve cone is unseated via the solenoid pin and ball, the control oil flows out and the main control (slide valve) opens the bypass connection. In this situation the motor does not rotate as there is no oil flow through the rotary parts.

**Motor controllers (Fig 6A & 6B)**

The motor controllers vary in relation to the motor controlled. However, all are essentially similar in operation, only the derivation of input signal is different, together with specific delays to avoid pressure peaks in the hydraulic system.

The controller, control valve solenoid and sensor/relay controls are connected via 2-pin plug connectors and cable. Line connections are shown in Fig 6A and 6B. Apart from a 2 amp fuse link there are no user serviceable items to this component.

The fan controller (Fig 6A) is electronic, Serck type 105, with an operating voltage of 20 to 34 volts dc and an output current of 0 to 1.5 amps. The controller provides an output voltage to the solenoid operated valve on the fan motor, from an input signal derived from a temperature sensor located in the radiator coolant inlet.

The regulating range extends from 40 to 100°C and within that range the regulating band width can be adjusted from 2 to 20°C. In the pre-set range (87 to 93°C) the fan motor speed is continuously regulated between zero and maximum. There is a time delay when regulating, this can be preset between 0.2 and 20 seconds. Failure of the controller will result in full fan speed.

The alternator controller (Fig 6B) is electronic, Serck type 105, with an operating voltage of 20 to 34 volts dc and an output current of 0 to 1.5 amps. The controller provides an output voltage to the solenoid operated value on the alternator motor, from an input signal derived from a time relay and control switch in the engine control circuit. This imposes a 30 sec delay after engine start and restart. There is no input to the controller until the relay has closed. A further 10 sec delay in the controller allows the motor to run up to speed from zero. Failure of this controller will result in full alternator speed.

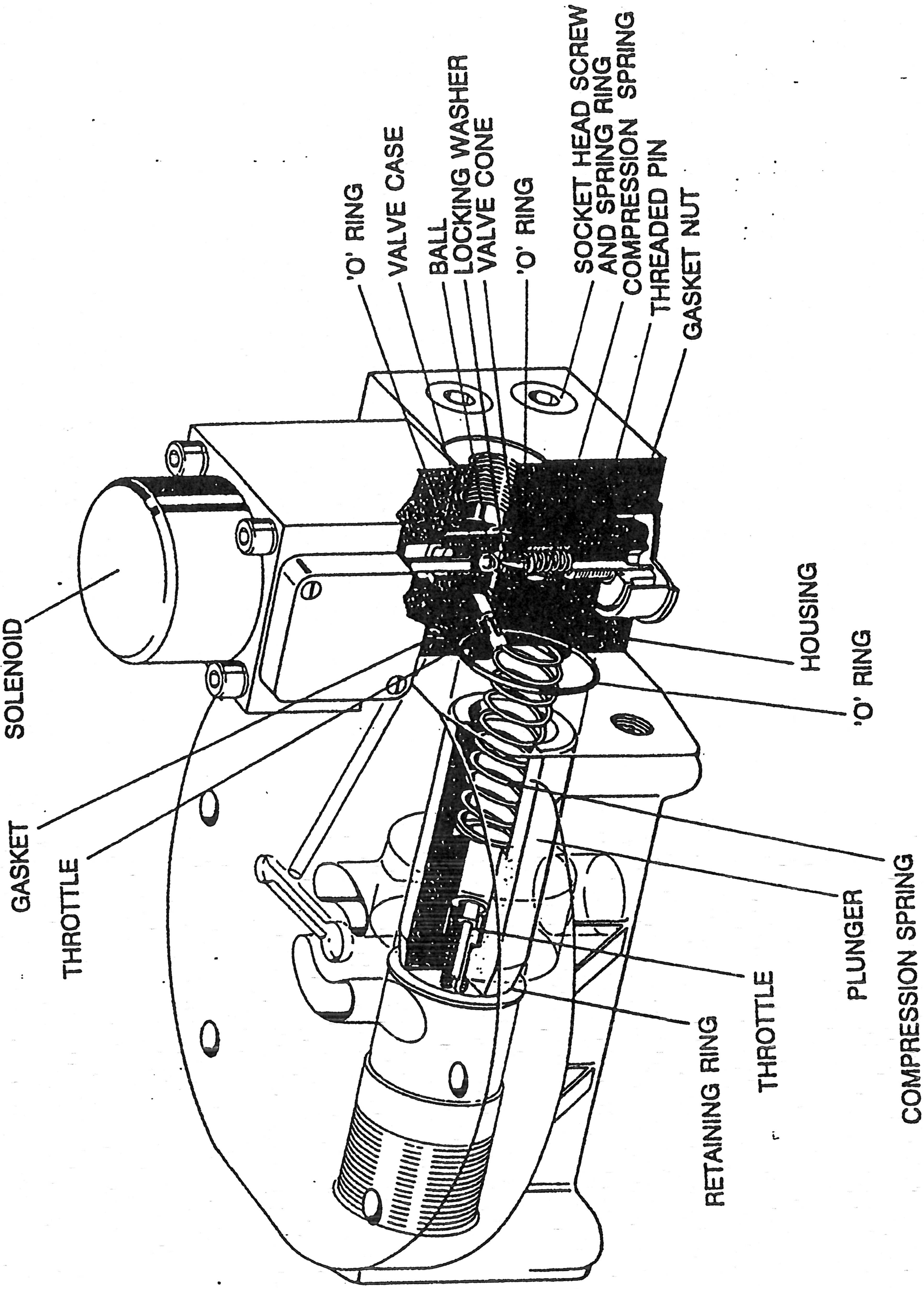
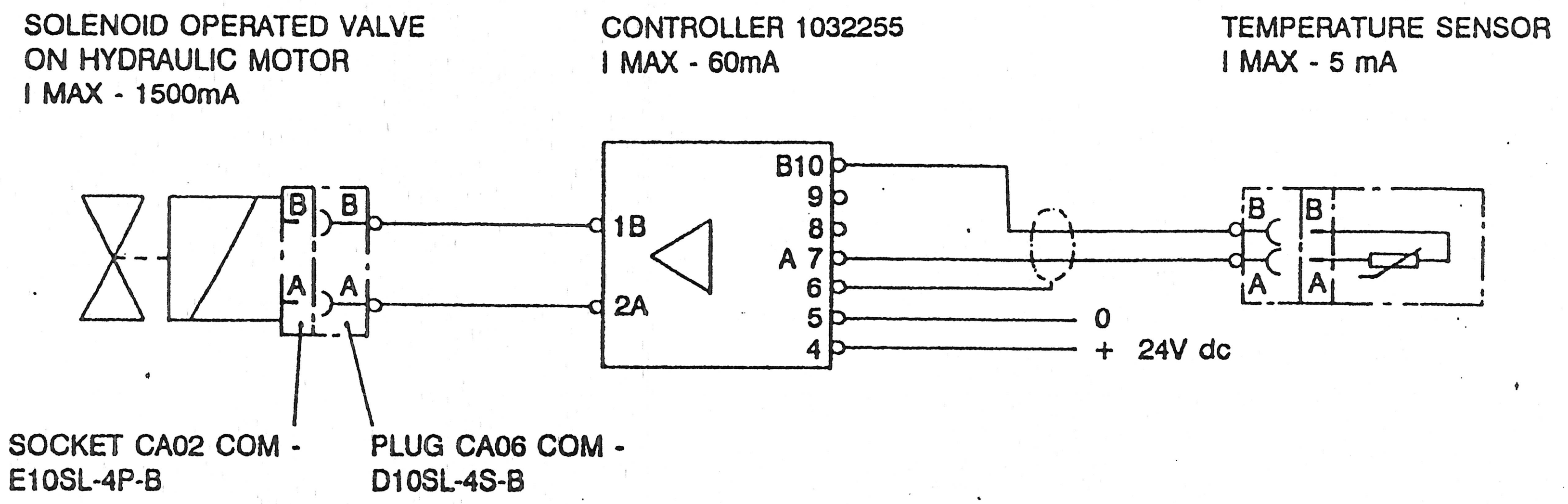
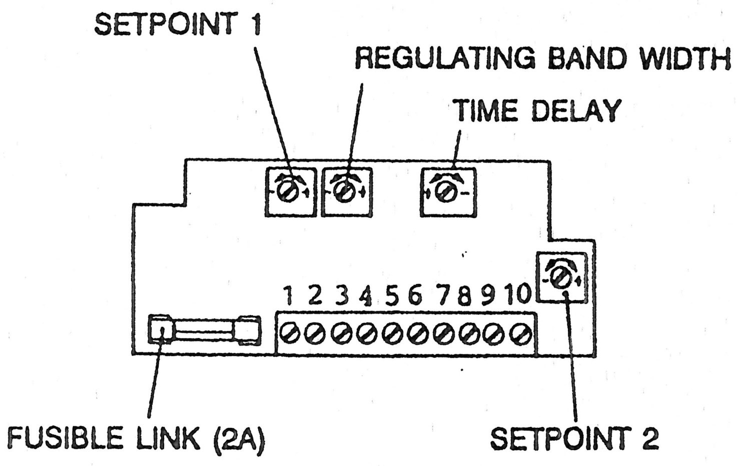

'O' RING
VALVE CASE
BALL
LOCKING WASHER
VALVE CONE
'O' RING
SOCKET HEAD SCREW AND SPRING RING
COMPRESSION SPRING
THREADED PIN
GASKET NUT
HOUSING
'O' RING
SOLENOID
GASKET
THROTTLE
COMPRESSION SPRING
PLUNGER
THROTTLE
RETAINING RING

Fig 5 Fan motor control valve


SOLENOID OPERATED VALVE
ON HYDRAULIC MOTOR
I MAX - 1500mA
CONTROLLER 1032255
I MAX - 60mA
TEMPERATURE SENSOR
I MAX - 5 mA
B
A
1B
2A
B10
9
8
A 7
6
5
4
0
+ 24V dc
SOCKET CA02 COM -
E10SL-4P-B
PLUG CA06 COM -
D10SL-4S-B


SETPOINT 1
REGULATING BAND WIDTH
TIME DELAY
1 2 3 4 5 6 7 8 9 10
FUSIBLE LINK (2A)
SETPOINT 2

TECHNICAL DATA:

| | |
|---|---|
| OPERATING VOLTAGE | 20V - 34V dc |
| OUTPUT CURRENT | 0 - 1.5A |
| CHOPPER FREQUENCY | 160 Hz APPROX |
| AMBIENT TEMPERATURE | -30C TO + 100C |
| TIME DELAY | 0,2 - 20 Sec |
| REGULATING BAND WIDTH | 2k - 20 K |
| REGULATING RANGE | +40C TO 100C |
| TEMPERATURE SENSOR | NTC 380 Hy |

ONCE POWER SUPPLY HAS CONNECTED THE UNIT STARTS TO
REGULATE ONLY AFTER THE SET DELAY
tHE FULLY CLOCKWISE POSITION (ZERO DELAY), NOT AT THE
EXTREME END OF THE SCALE
SET POINT 2 POTENTIOMETER MUST BE SET FULLY ANTICLOCKWISE

Fig 6A Motor (fan) controller

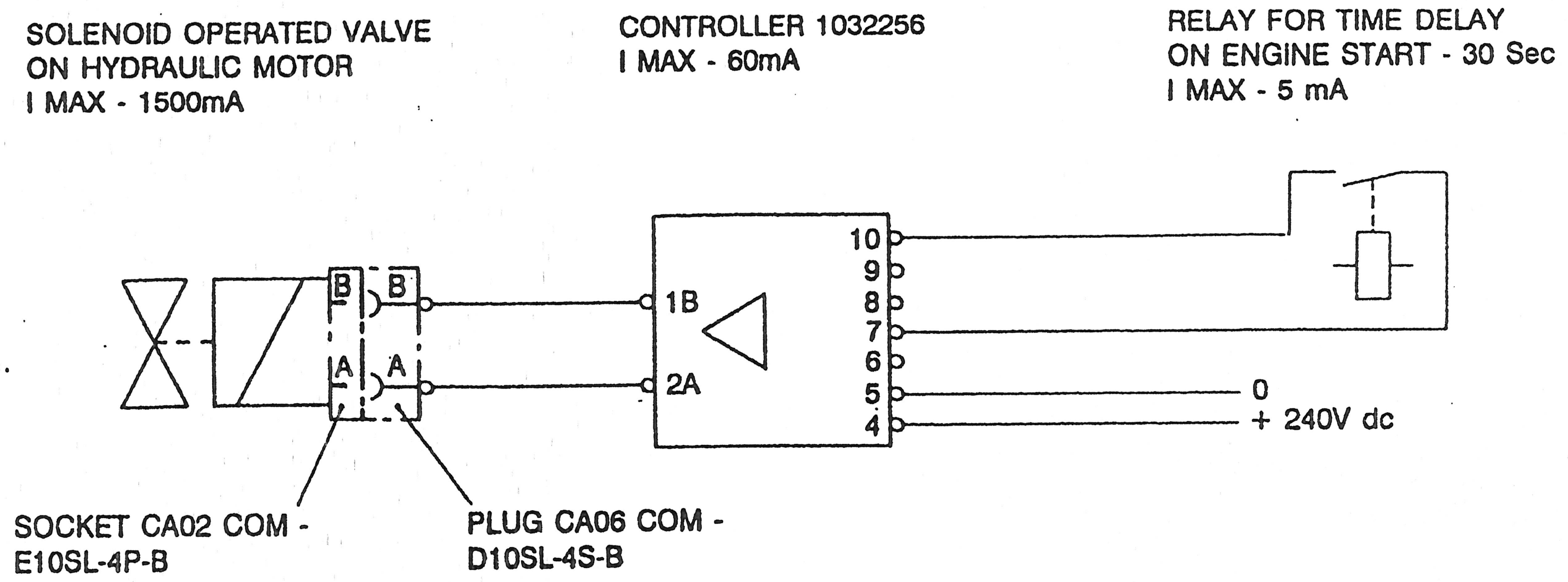

SOLENOID OPERATED VALVE
ON HYDRAULIC MOTOR
I MAX - 1500mA
CONTROLLER 1032256
I MAX - 60mA
RELAY FOR TIME DELAY
ON ENGINE START - 30 Sec
I MAX - 5 mA
B
B
A
A
1B
2A
10
9
8
7
6
5
4
0
+ 240V dc
SOCKET CA02 COM -
E10SL-4P-B
PLUG CA06 COM -
D10SL-4S-B

Fig 6B Motor (alternator) controller

CONTROLLER

THE TIME DELAY IS SET TO APPROXIMATELY 10 Sec AS STANDARD WHEN THE TIMING RELAY SWITCHES THE MOTOR SPEED STEADILY INCREASES FROM ZERO TO MAXIMUM WITHIN THE PERIOD OF DELAY

TIMING RELAY FOR START UP DELAY

THE TIMING RELAY IS SWITCHED SUCH THAT BOTH DURING STARTING AND REPEAT STARTING OF THE DIESEL ENGINE THE CIRCUIT IS BROKEN FOR 30 SECONDS. THUS WHEN THE DIESEL ENGINE IS STARTED THE ALTERNATOR WILL BEGIN TO RUN 30 SECONDS LATER THAN THE ENGINE

TECHNICAL DATA:

| | |
|---|---|
| OPERATING VOLTAGE | 20V - 34V dc |
| OUTPUT CURRENT | 0 - 1.5A |
| CHOPPER FREQUENCY | 160 Hz APPROX |
| AMBIENT TEMPERATURE | -30C TO + 100C |
| TIME DELAY | 0,2 - 20 Sec |

## Oil reservoir (Fig 7)

The hydraulic system is supplied with fluid from the hydraulic oil reservoir under all conditions of operation. The reservoir also incorporates a filter to clean the hydraulic oil before it is recirculated to the fan pump and system.

An injector in the oil reservoir returns the oil into the hydraulic circuit, producing a slight overpressure in the suction line which ensures that both pumps are supplied with sufficient hydraulic oil at all times. This prevents damage which may result from cavitation.

The upper portion of the oil reservoir contains the filter chamber, this is connected to the return line and houses the vent filter. An injector is arranged beneath the filter and is connected to the suction line of the pumps at the bottom of the reservoir.

The size of the reservoir allows the oil volume to increase or decrease, which occurs whenever the hydraulic oil heats and thereby expands while the hydrostatic system is in operation. The reservoir has a large volume sufficient to allow for drainback of the pipework above the reservoir when the system is not working. Another purpose of the oil reservoir is to vent the hydraulic circuit and a vent filter is fitted for this purpose.

The vent and its filter are on the upper part of the reservoir. At the side of the oil reservoir there is a sight glass with a maximum and a minimum level mark from which the oil level is read.

The filler neck projects from the top of the oil reservoir. The filter chamber and the oil reservoir can be drained through openings in the bottom. The oil reservoir is arranged in an elevated position relative to the variable displacement pump on the alternator raft.

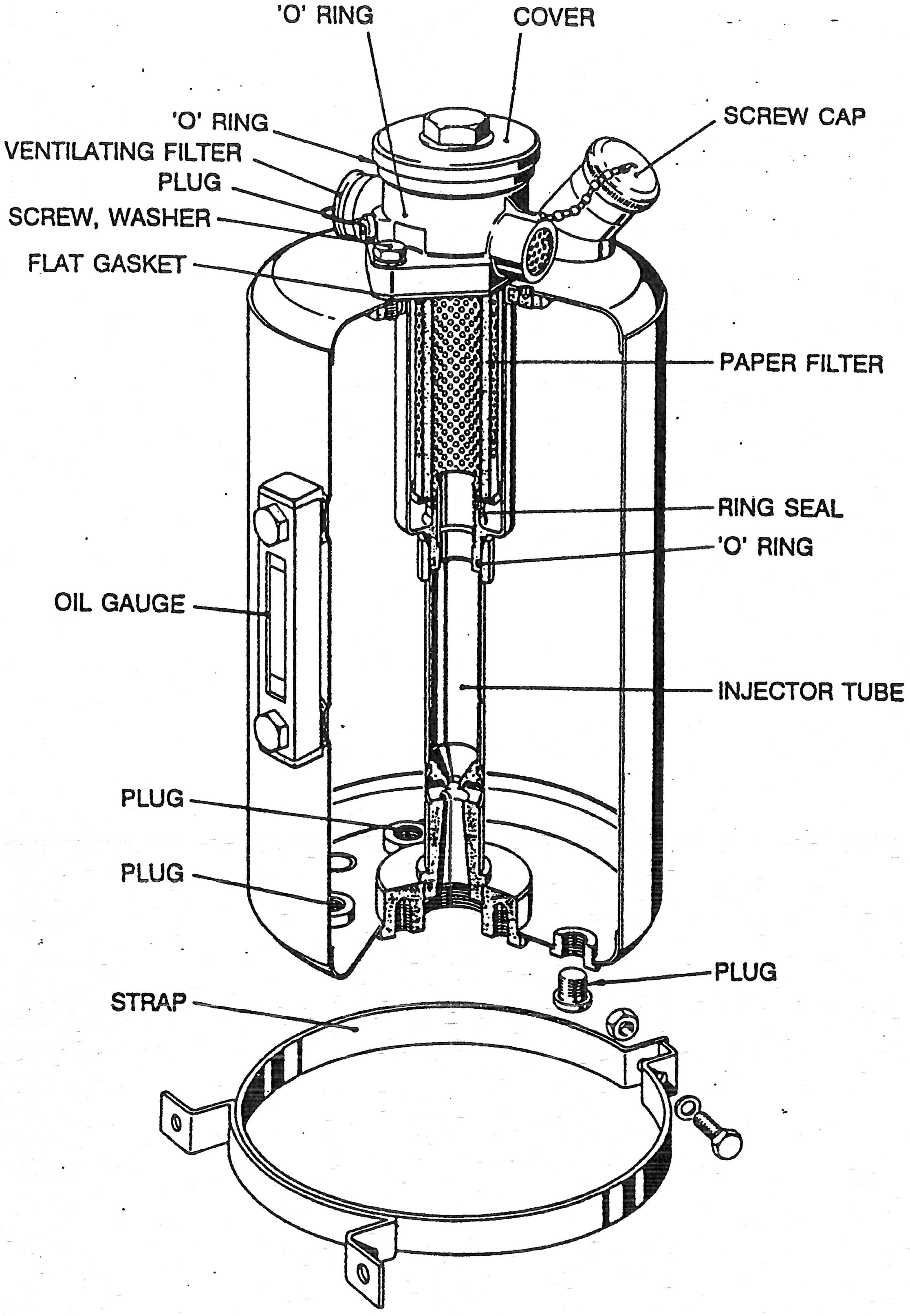
The returning oil from the hydraulic circuit enters the filter chamber and passes through the filter. Any steel and dirt particles are separated and retained by the filter. The filtered oil flows into the injector where it is accelerated and passes to the pumps at a slight overpressure.

Hydraulic oil from the reservoir is taken in through the injector tube, the drip oil (pump leakage connection) is returned to the circuit in this way.

The injector tube also allows air entrained in the lines to pass into the oil reservoir, where is it released through the vent filter. This can occur when a freshly charged system is started for the first time. The vent also prevents the ingress of dirt into the system.

## Leakage oil filter

Dirt in the oil is the major cause of problems in the hydrostatic system and a fine filter is placed in the leakage return line to the reservoir to control the contamination level in the oil. This is a by-pass filter, due to the small leakage flow through it, it takes some time for all the oil in the system to be cleaned.


'O' RING
COVER
'O' RING
VENTILATING FILTER
PLUG
SCREW, WASHER
FLAT GASKET
SCREW CAP
PAPER FILTER
RING SEAL
'O' RING
OIL GAUGE
INJECTOR TUBE
PLUG
PLUG
PLUG
STRAP

ig 7 **Hydraulic oil reservoir**

## Alternator motor and drive (Fig 8)

The main internal components and operation of the alternator motor, Serck type TT11/40 MR, are similar to the fan motor (see Fig 4).

The only significant changes are the provision of a drive coupling between motor and alternator (see Fig 8) and method of control. The operating principle is the same.

The motor solenoid control valve is actuated via a Serck type 105 controller (see Fig 6B and text).

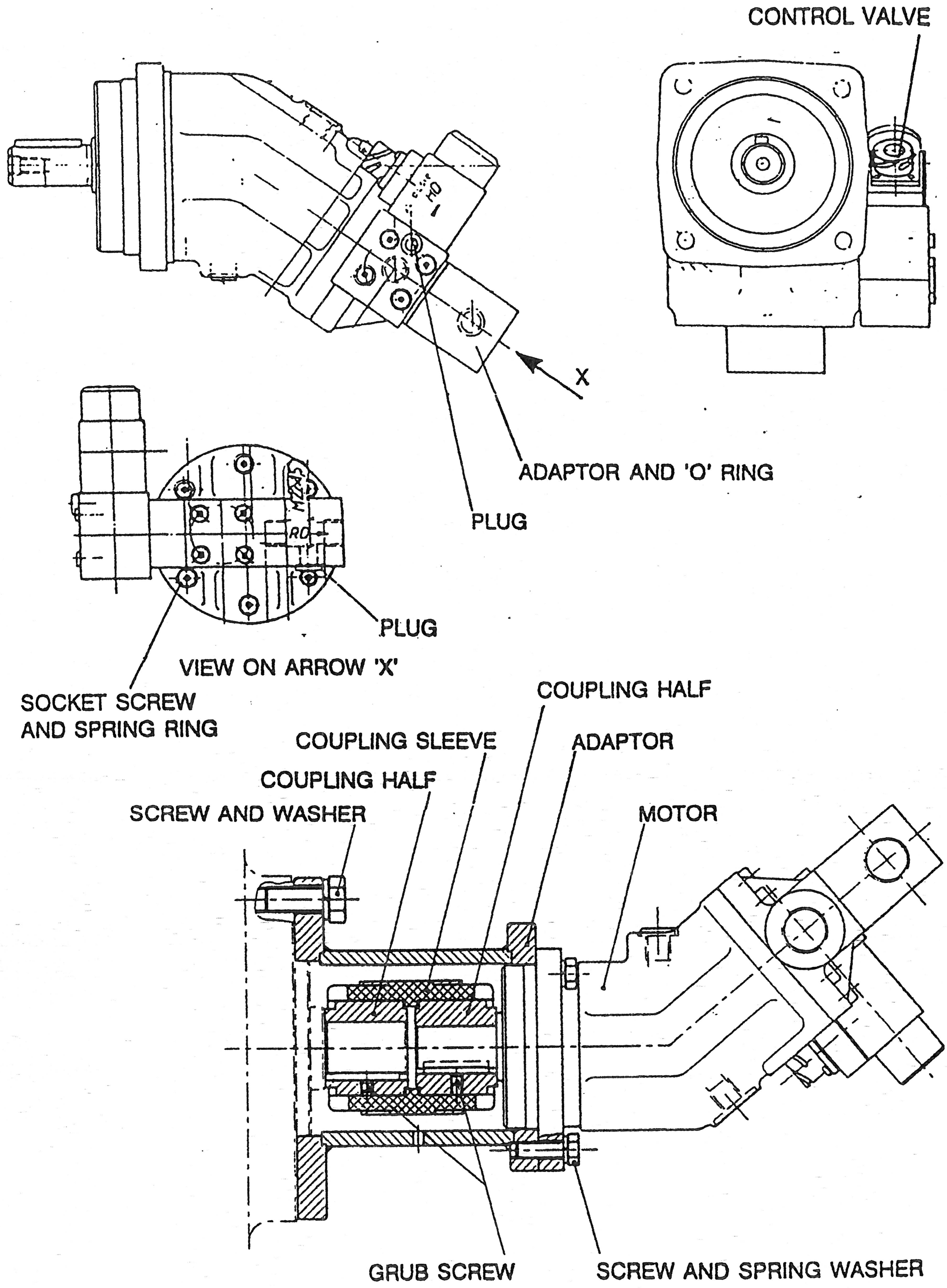

CONTROL VALVE
X
ADAPTOR AND 'O' RING
PLUG
RD
PLUG
VIEW ON ARROW 'X'
SOCKET SCREW
AND SPRING RING
COUPLING HALF
COUPLING SLEEVE
ADAPTOR
COUPLING HALF
SCREW AND WASHER
MOTOR
GRUB SCREW
SCREW AND SPRING WASHER

Fig 8 Alternator motor drive assembly

## Fault Diagnosis

### Introduction

This fault diagnosis chart is included to identify the faults that can develop during operation of the hydrostatic system, and remedial action to be taken to rectify the fault.

### Radiator fan drive

Because there are no engine instruments in the cab, the only driver indication of a fan system fault will be an engine reverting to idle.

**FAULT** **Coolant system overheating (engine reverting to idle due to high cooling water temperature).**

| CAUSE | REMEDY |
|---|---|
| Low oil level | Check reservoir level and refill. Check for leaks |
| Radiator matrix obstruction | Clean the radiator |
| Fan motor bypass remains open (fan fails to cut in) | Check fan controller operation and sensor. Change if needed. |
| Engine over-temperature | Test the over-temperature switch. Change if needed |
| Pump motor failed | Check mechanical drive |
| Fan motor failed | check pipework connection |

### Alternator drive

**FAULT** **Alternator failure - mechanical - no output**

| CAUSE | REMEDY |
|---|---|
| Low oil in system | Check reservoir level and refill. Check for leaks |
| Drive motor bypass remains open | Check controller operation. Change if needed. |
| Engine time delay or circuit | Test the control circuit/components. Change if needed. |
| Variable displacement fails | Check mechanical drives |
| Drive motor failed | Check pipework connections |

# CLASS 166

## Introduction

The hydrostatic system used is a development of that fitted to Class 165 vehicles with the addition of an air conditioning condenser unit. Some components have been increased in capacity or relocated in the circuit to accommodate the additional power demand associated with the air conditioning system.

The cooler group fan drive is now fed from the return line of the auxiliary drive system. This fan drive loop is protected by its own in-line filter.

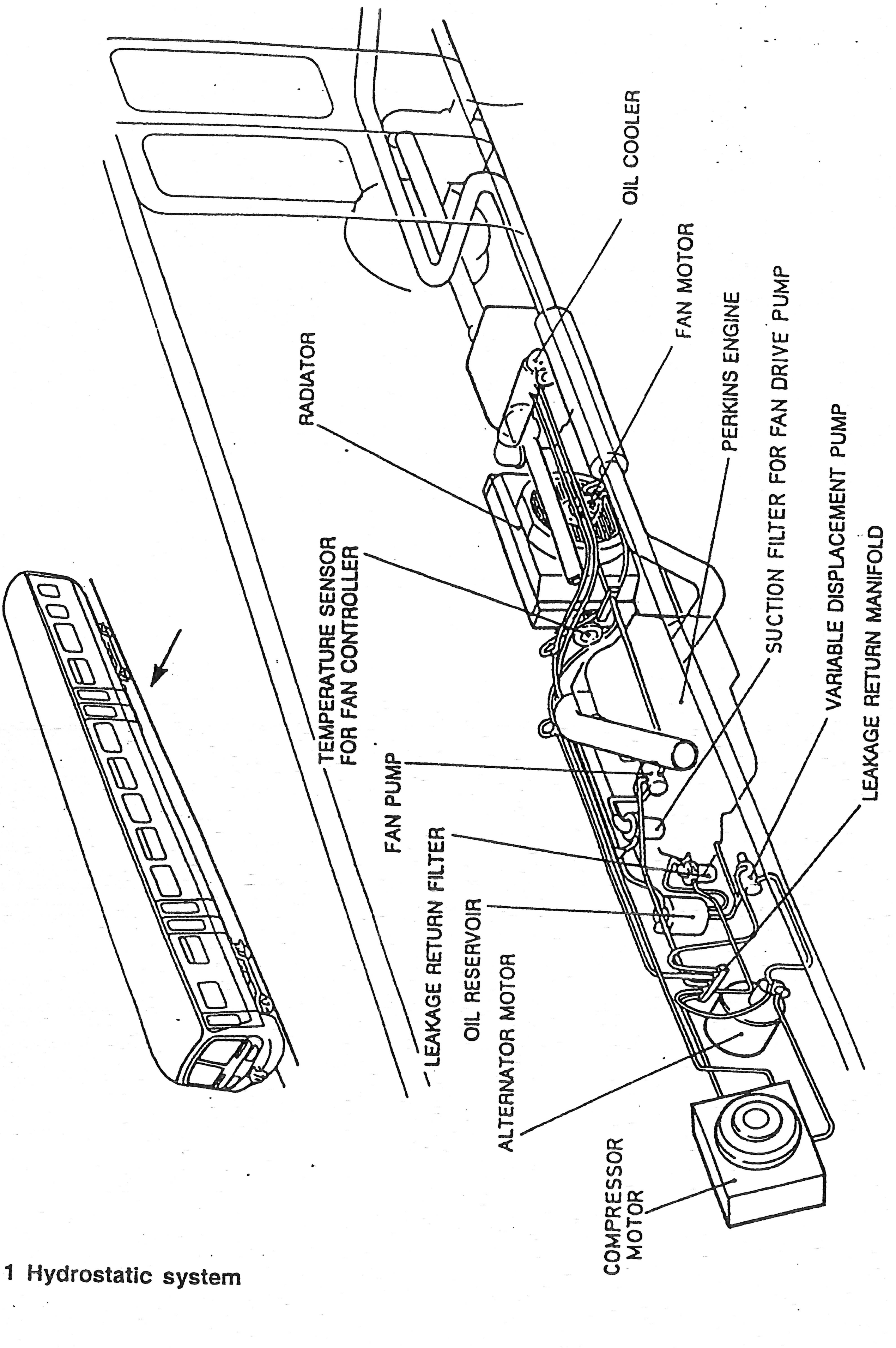

OIL COOLER
FAN MOTOR
PERKINS ENGINE
SUCTION FILTER FOR FAN DRIVE PUMP
VARIABLE DISPLACEMENT PUMP
LEAKAGE RETURN MANIFOLD
RADIATOR
TEMPERATURE SENSOR
FOR FAN CONTROLLER
FAN PUMP
LEAKAGE RETURN FILTER
OIL RESERVOIR
ALTERNATOR MOTOR
COMPRESSOR
MOTOR

Fig 1 Hydrostatic system

## System Components

### Variable displacement pump

A variable displacement pump, Serck type T25 PL, is mounted on the alternator raft. The pump is driven from the free end of the engine crankshaft via a driveshaft with universal joints and a torsionally flexible coupling. The pump supplies the alternator and air conditioning compressor drive motors.

The control system adjusts the pump output to give a constant flow of oil as the engine speed varies. Below an engine speed of 920 rpm the pump is at maximum stroke, so the flow is then directly related to engine speed, and the speed of the alternator and compressor fall in proportion.

### Fan pump

A Serck type T11/40 PR pump is fitted to an auxiliary drive located at the top of the free end of the engine. Pump output is fixed per revolution and so is directly related to engine speed.

### Motor Controls

Serck Behr electronic controllers are used to stop and start the three drive motors fitted to the system.

### Fan drive motor

A Serck type T10/40 ML hydraulic motor with fan is fitted to provide the cooling air fan low through the engine radiator. The motor is similar in construction to the engine mounted pump.

### Alternator drive motor

A Serck type T13/30 MR hydraulic motor, with drive, is fitted to the alternator unit. The motor is similar in construction and operation to the fan motor.

### Air conditioning compressor drive motor

A Serck type T17/40 ML hydraulic motor, with drive, is fitted to the air conditioning compressor unit. The motor is similar in construction and operation to the fan motor.

### Fan pump filter

A replacement element type filter is fitted in the fan pump suction line. This provides full flow filtering of the oil, which is drawn from the cooler to oil tank return line.

### Hydraulic oil reservoir

because of size limitation the 166 hydraulic oil reservoir has been modified and is rectangular in construction, however it still fulfils the same function as the 165 reservoir and includes a replacement filter element and breather filter.

**Leakage oil return filter**

The system is fitted with a replacement element spin-on cartridge type filter, in addition to the filter within the reservoir body. This is a much finer filter than that fitted to the reservoir, but only cleans the small leakage flow.

The filter is mounted adjacent to the reservoir on the alternator raft.

**Hydraulic oil cooler**

This provides cooling for the hydraulic system.

## System function

The function of the vehicle hydrostatic system to provide a drive to the alternator coolant radiator fan and air conditioning system compressor. This is achieved by circulating hydraulic fluid through a closed loop circuit which incorporates drive motors to these units. Although each of these units independently, it follows that if the engine is not running the associated system will be non-operational.

There are two hydraulic circuits. One circuit comprises the variable displacement pump and the motor for the air conditioning compressor, alternator and the reservoir. The other consists of the engine mounted pump and the motor for the cooler group. This is a loop off the other circuit.

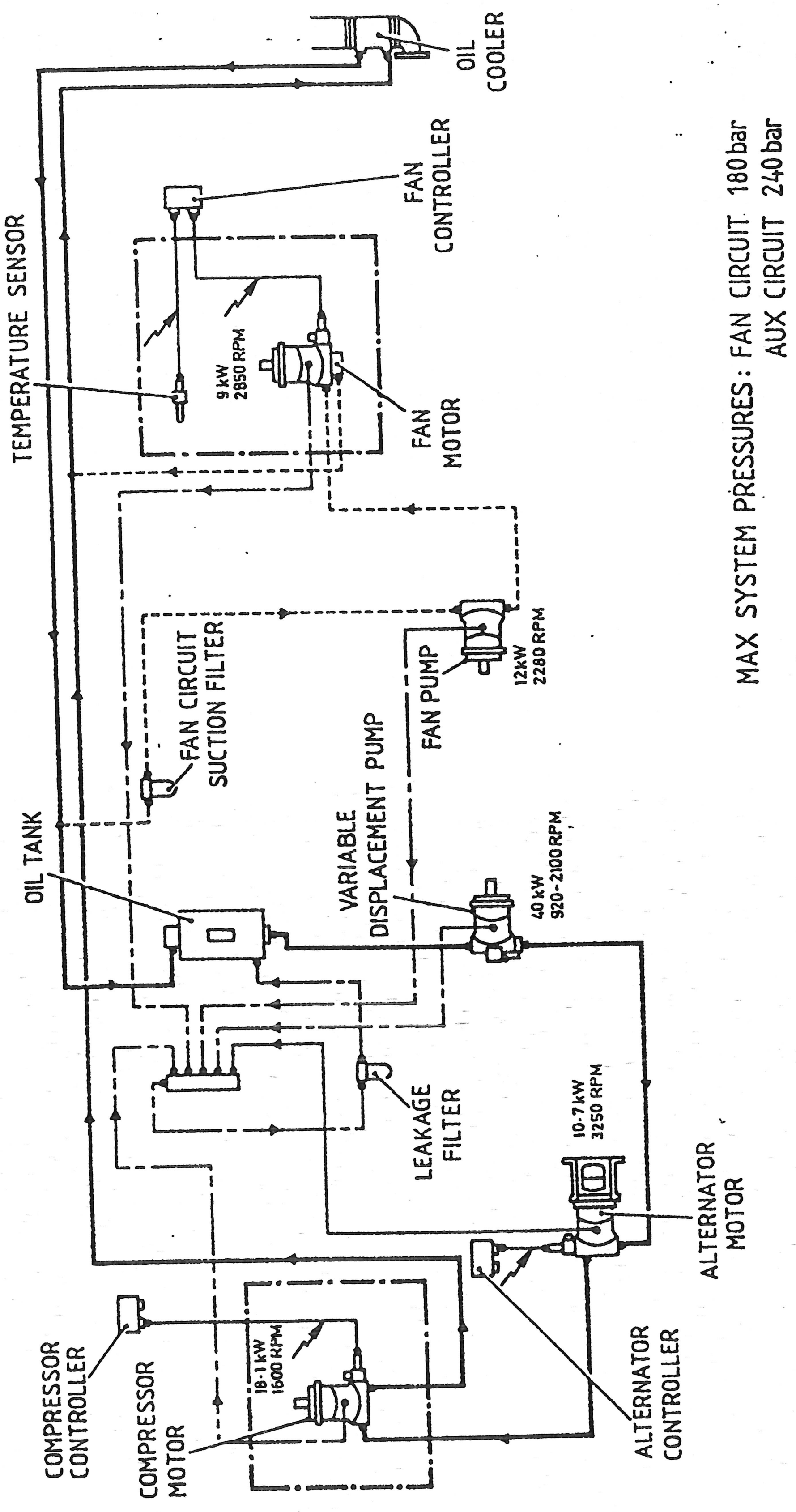
### Hydrostatic system drives

The system comprises three separate drives to system component items; alternator, air conditioning compressor and radiator fan.

A variable displacement pump driven from the engine crankshaft supplies hydraulic fluid under pressure to the alternator drive motor and the air conditioning compressor motor. A separate pump supplies fluid to the radiator fan motor. Each motor is individually controlled in respect of the equipment served.

### Alternator and Air Conditioning Compressor drives

With the engine running, the fluid from the variable displacement pump is circulated first to the alternator and then to the air conditioning compressor motor. The fluid then returns to the reservoir after first passing through the hydraulic oil cooler. Both motors operate as dictated by their respective controllers.


OIL COOLER
FAN CONTROLLER
TEMPERATURE SENSOR
9 kW 2850 RPM
FAN MOTOR
FAN CIRCUIT SUCTION FILTER
12kW 2280 RPM
FAN PUMP
OIL TANK
VARIABLE DISPLACEMENT PUMP
40 kW 920-2100 RPM
LEAKAGE FILTER
10·7 kW 3250 RPM
ALTERNATOR MOTOR
ALTERNATOR CONTROLLER
18·1 kW 1600 RPM
COMPRESSOR MOTOR
COMPRESSOR CONTROLLER

MAX SYSTEM PRESSURES : FAN CIRCUIT 180 bar
AUX CIRCUIT 240 bar

Fig 1 Hydrostatic system schematic

## System components

### Alternator motor and drive

The main internal components and operation of the alternator motor, Serck type T13/40 MR, are similar to the fan motor.

The only significant differences are the provision of a drive coupling between motor and alternator and the method of control.

The motor solenoid control valve is actuated via Serck type 105 controller.

### Air conditioning compressor motor

The main internal components and operation of the air conditioning compressor motor, Serck type T17/40 ML, are similar to the fan motor. The only significant differences are the provision of an indirect drive to the condenser fan and method of control.

The motor solenoid control valve is actuated via a Serck type 106 controller. See fig 2.

### Motor controllers

The motor controllers vary in relation to the motor controlled. However, all are essentially similar in operation, only the derivation of signal of different, together with specific delays to avoid pressure peaks in the hydraulic system.

The controller, control valve solenoid and sensor/relay controls are connected via 2-pin plug connectors and cable. Apart from a 2 amp fuse link there are no user serviceable items to this component.

The air conditioning compressor motor controller (fig 2) is electronic, Serck type 106, with an operating voltage of 20 to 34 volts dc and an output current of 0 to 0.5 amps. The controller provides an output voltage to the solenoid operated valve on the air conditioning compressor motor from an input signal derived from a time relay and control sensor in the air conditioning control circuit. The air conditioning compressor motor start-up is subject to a 60 second delay on engine start-up, with a further 10 second delay while the air conditioning compressor runs up to speed from zero. Failure of this controller will result in a non-operation of the air conditioning unit.

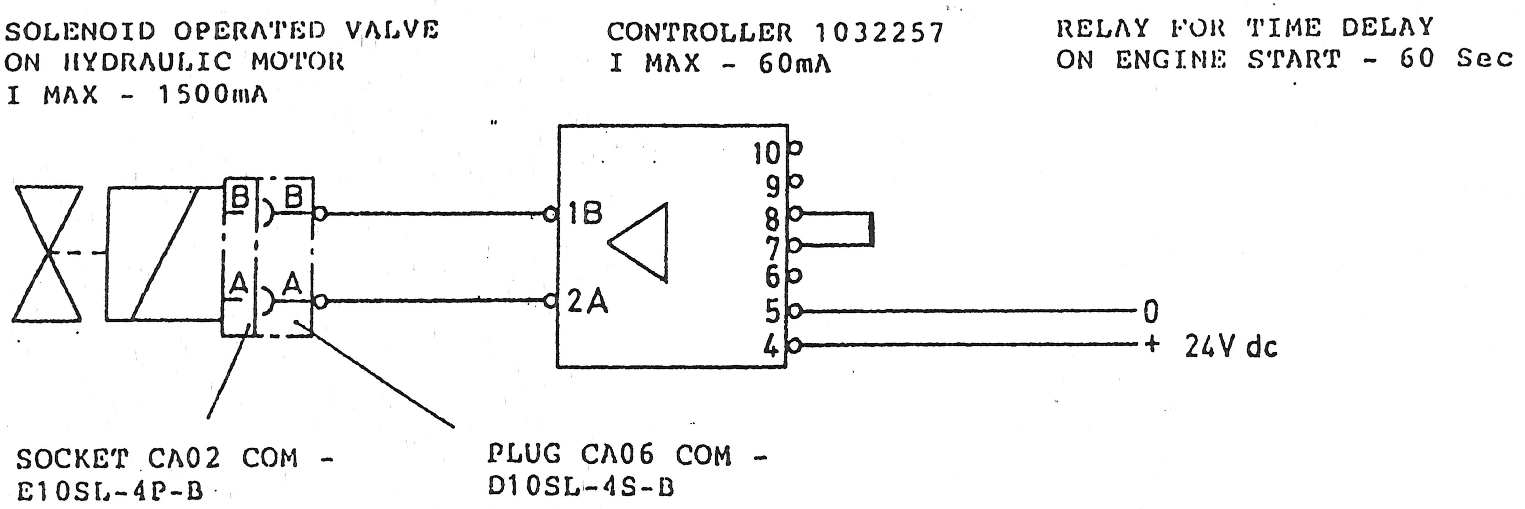

SOLENOID OPERATED VALVE
ON HYDRAULIC MOTOR
I MAX - 1500mA
CONTROLLER 1032257
I MAX - 60mA
RELAY FOR TIME DELAY
ON ENGINE START - 60 Sec
B
B
A
A
1B
2A
10
9
8
7
6
5
4
0
+ 24V dc
SOCKET CA02 COM -
E10SL-4P-B
PLUG CA06 COM -
D10SL-4S-B

Fig 2 Motor controller schematic

TECHNICAL DATA:

| | |
|---|---|
| OPERATING VOLTAGE | 20v - 34V dc |
| OUTPUT CURRENT | 0 - 1.5A |
| CHOPPER FREQUENCY | 160 Hz APPROX |
| AMBIENT TEMPERATURE | -30C TO + 100C |
| TIME DELAY | 0,2 - 20Sec |

CONTROL SWITCH

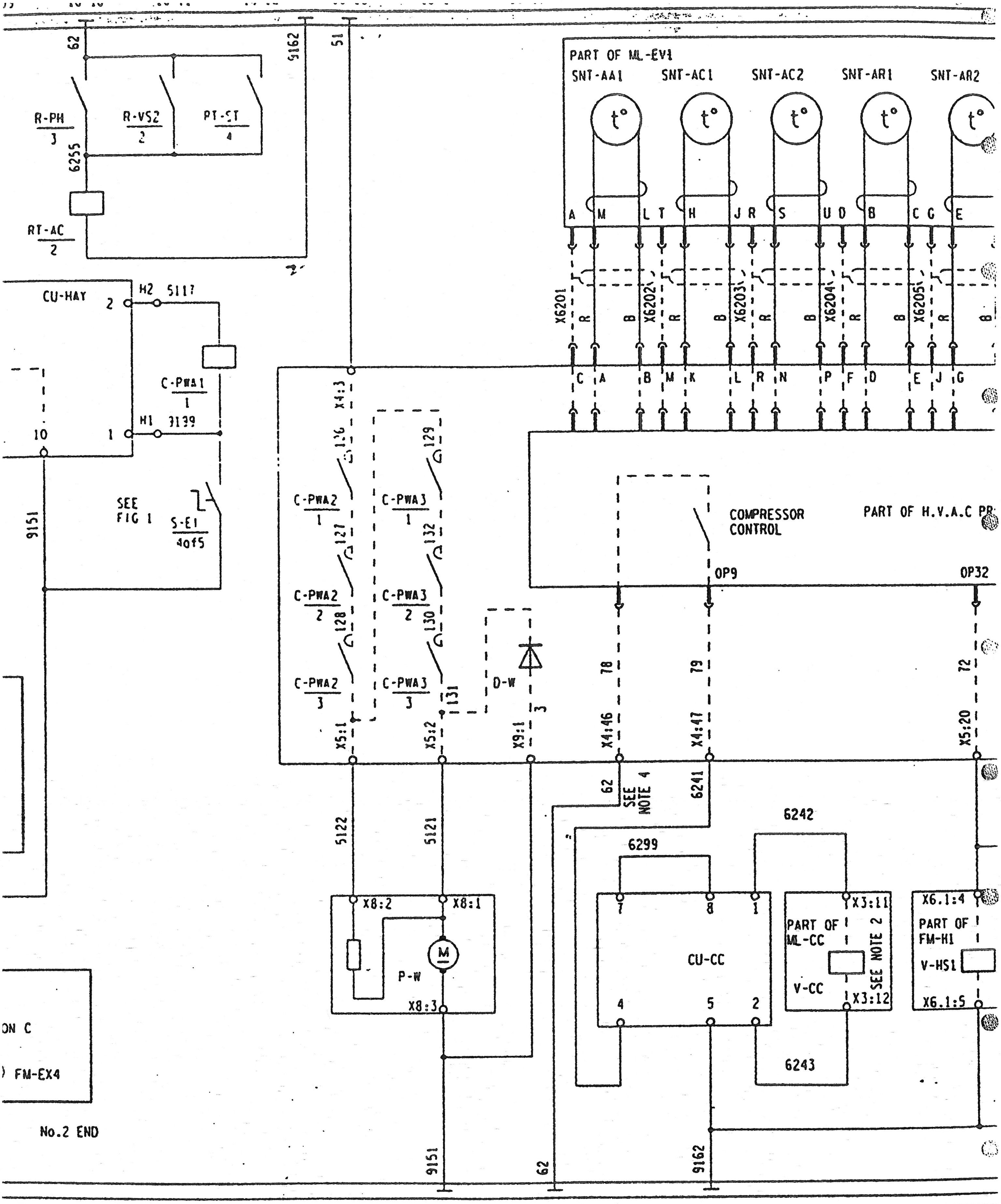
THE CONTACTS MUST CLOSE WHEN THE MOTOR IS REQUIRED TO RUN

CONTROLLER

THE TIME DELAY IS SET TO APPROXIMATELY 10 Sec AS STANDARD WHEN THE CONTROL SWITCH OPERATES THE MOTOR SPEED STEADILY INCREASES FROM ZERO TO MAXIMUM WITHIN THE PERIOD OF DELAY OR FALLS STEADILY FROM MAXIMUM TO ZERO

TIMING RELAY FOR START UP DELAY

THE TIMING RELAY IS SWITCHED SUCH THAT BOTH DURING STARTING AND REPEAT STARTING OF THE DIESEL ENGINE THE CIRCUIT IS BROKEN FOR 60 SECONDS. THUS WHEN THE DIESEL ENGINE IS STARTED THE CONTROL SWITCH IS OVERRIDDEN BY THE TIMING RELAY SO THE COMPRESSOR STARTS 60 SECONDS LATER THAN THE ENGINE


62
9162
51
R-PH
3
R-VS2
2
PT-ST
4
6255
RT-AC
2
PART OF ML-EV1
SNT-AA1
SNT-AC1
SNT-AC2
SNT-AR1
SNT-AR2
t°
A M L T H J R S U D B C G E
X6201
X6202
X62031
X6204
X62051
R
B
C A B M K L R N P F D E J G
CU-HAY
H2 5117
2
C-PWA1
1
H1 3139
10
1
SEE FIG 1
S-E1
4of5
9151
X4:3
126
129
C-PWA2
1
C-PWA3
1
127
132
C-PWA2
2
C-PWA3
2
128
130
C-PWA2
3
C-PWA3
3
131
D-W
3
COMPRESSOR CONTROL
PART OF H.V.A.C PR
OP9
OP32
78
79
72
X5:1
X5:2
X9:1
X4:46
X4:47
X5:20
62
SEE NOTE 4
6241
5122
5121
6242
6299
X8:2
X8:1
M
P-W
X8:3
7
8
1
CU-CC
4
5
2
X3:11
PART OF ML-CC
V-CC
SEE NOTE 2
X3:12
X6.1:4
PART OF FM-H1
V-HS1
X6.1:5
6243
ON C
FM-EX4
No.2 END
9151
62
9162

BOOST PUMP

COMPRESSOR CONTROL

| ISS | GRID REF | ALTERATIONS |
|---|---|---|
| | | |

Controlled

388)

NOTES:
1. ST-HAY OPENS AT 70°C RISING & CLOSES AT 65°C FALLING. IT IS MOUNTED IMMEDIATELY DOWN STREAM OF H-AY.
2. V-CC ENERGISES WITHIN 10 SECONDS AFTER OP9 ENERGISES TO ALLOW COMPRESSOR & CONDENSER FAN TO RUN.
3. THIS DRG TO BE READ IN CONJUNCTION WITH 1122250.1122252 & 1126803.
4. VEHICLES WITHIN RANGE 58601-58621.WIRE 62 CONNECTION TO CU-AC PIN X4:46 IDENTIFIED

| | | |
|---|---|---|
| F | SEPT 95 | DJG |
| E | 25-03-93 | RJH |
| D | 27-08-92 | PLW |
| C | 14-07-92 | PL |

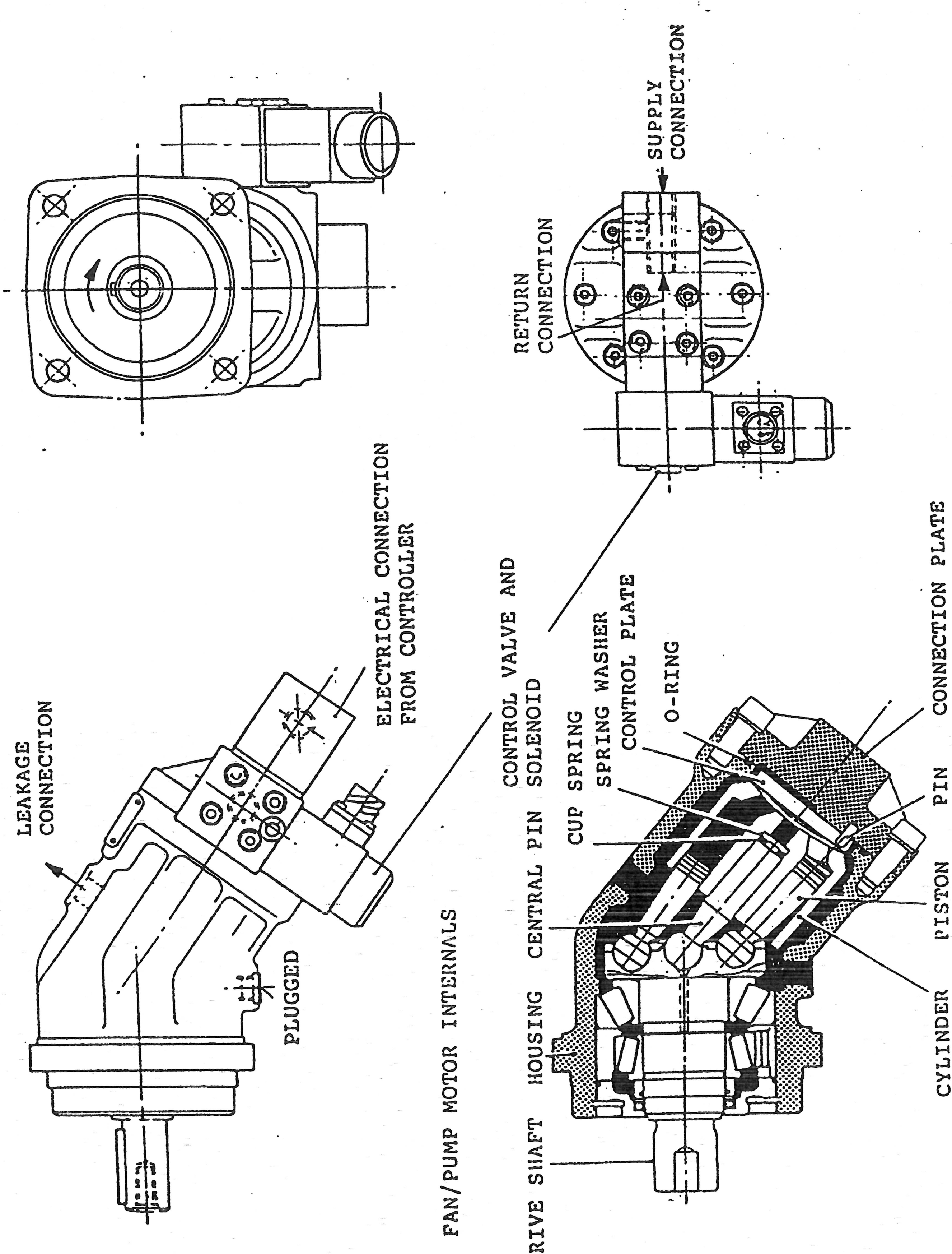

LEAKAGE CONNECTION
PLUGGED
ELECTRICAL CONNECTION FROM CONTROLLER
CONTROL VALVE AND SOLENOID
RETURN CONNECTION
SUPPLY CONNECTION
FAN/PUMP MOTOR INTERNALS
DRIVE SHAFT
HOUSING
CENTRAL PIN
CUP SPRING
SPRING WASHER
CONTROL PLATE
O-RING
CONNECTION PLATE
PIN
PISTON
CYLINDER

Fig 3 Air conditioning compressor motor

# Fault diagnosis

## Introduction

This fault diagnosis chart is included to identify the faults that can develop during operation of the hydrostatic system and the remedial action to be taken to rectify the fault.

## Air conditioning compressor drive

**FAULT** **Air conditioning compressor failure - mechanical - temperature rise in air conditioning system**

| CAUSE | REMEDY |
|---|---|
| Low level in system | Check reservoir level and refill. Check for leaks |
| Drive motor bypass remains open | Check controller operation. Change if needed |
| Engine time delay relay or circuit faulty | Test control circuit/components.<br>Change if needed |
| Variable displacement pump and/or drive motor failed | Check pipework connections and/or mechanical drive |
| Thermostat sensor faulty | Test thermostat sensor/s on air conditioning system. Change if needed |

## Motors

**FAULT** **Motor will not run (fan and alternator)**
**Motor will not run (compressor)**
**Motor will not run (all)**

| CAUSE | REMEDY |
|---|---|
| Controller or electrical fault | Remove plug from solenoid if motor runs check wiring. Connect 24 V dc to solenoid if motor runs check wiring |
| No oil supply | Check pressure from pump<br>Check oil level in tank |
| Seized or damaged motor | Ensure motor will rotate freely - if not replace |

**Motors - continued**

**FAULT** **Motor runs slowly**

| **CAUSE** | **REMEDY** |
|---|---|
| Inner leakage due to wear | Check leakage oil flow rate, replace motor if necessary |
| Insufficient oil flow | See under pump section |
| Pressure limiter valve set incorrectly | Replace motor and have it recalibrated. |

**FAULT** **Motor speed fluctuates**

| **CAUSE** | **REMEDY** |
|---|---|
| Air in hydraulic oil | See under pump section |

**FAULT** **Fan motor runs at full speed continuously**

| **CAUSE** | **REMEDY** |
|---|---|
| Controller fault | Replace controller |
| Electrical fault | Check wiring and supply |
| Temperature sensor fault | Replace sensor and check wiring |

**FAULT** **Excessive noise**

| **CAUSE** | **REMEDY** |
|---|---|
| Mechanical damage to bearings or rotary group | Replace motor |

**Pumps**

**FAULT** **No oil flow or pressure**

| **CAUSE** | **REMEDY** |
|---|---|
| Drive failure to pump | Check coupling |
| No oil supply to pump | Check oil level in tank |

**pumps - continued**

**FAULT** **Low oil flow or pressure**

| **CAUSE** | **REMEDY** |
|---|---|
| Worn or damaged pump | Check leakage oil flow rate - replace pump if necessary |
| Insufficient oil supply | Check suction pipe for obstruction or leaks |

**FAULT** **Excessive noise**

| **CAUSE** | **REMEDY** |
|---|---|
| Cavitation due to air in hydraulic oil | Check oil level in tank.<br>Check suction pipe for leaks. |
| Mechanical damage to bearings or rotary group | Replace pump |

# Charging System

## INTRODUCTION

The current for charging the vehicle start and auxiliary batteries is provided by an alternator together with an associated control box. The alternator is a hydrostatically driven, constant voltage unit and is bolted to a suspension raft on the underframe. The raft is secured to the underframe through flexible mounts.

The control box is located next to the alternator and is also bolted to the suspension raft. Alternator output is rectified and regulated via the control box.

## ALTERNATOR DRIVE

The alternator is hydrostatically driven from an engine driven variable displacement pump mounted on the suspension raft.

The variable displacement pump is directly driven by a drive shaft from an auxiliary engine output.

## ALTERNATOR (Fig 1)

### Description

The alternator assembly consists of a wound stator and a rotor assembly. The rotor is formed by a shaft which provides a mounting for 240 steel laminations. These are heat shrunk onto the shaft and held in position by a web at each end. The shaft is supported at its drive end by a roller bearing and at its non-drive end bearing locates between an internal cap and one stop ring. Both bearings are covered by external caps which are bolted to flanges attached to the stator casing at each end.

The rotor is keyed at its drive end and is driven by the hydrostatic motor to rotate within the stator. The stator is made up from a solid stack of magnetic steel laminations. The laminations are slotted to provide a location for two field windings and six, 3 phase, ac windings. The stator is wound in a delta parallel configurations and output is delivered, via insulated cables, to a connection box mounted externally on the unit. The connection box holds a terminal board, which permits cable connection, and is protected by a cover.

### Specifications

| | |
|---|---|
| Model: | Statodyne Type 8 KSI 07.14 |
| Weight: | 123 Kg |
| Speed: | 3000/4000 rpm |
| Power rating: | 10 kW |
| DC Voltage: | 28.5 V |
| DC Current: | 300 A |

## ALTERNATOR CONTROL BOX

The control box acts as a rectifier and voltage regulator and consists of a diode bridge main rectifier and a voltage regulator.

The regulator consists of the following items:-

- field transformed
- magnetic amplifier
- field rectifier
- voltage detector PCB

The regulator maintains the level of charge voltage at 28.5 V +1 % and limits the total maximum current to 300 A +5%.

# APPENDIX 1

**Table showing the relationship between coolant temperature and output from the control unit to the radiator motor control valve solenoid. NB Figures accurate at time of publication.**

| Temperature - Degrees C | Voltage across control valve solenoid |
|---|---|
| 84 | 15.8 |
| 85 | 14 |
| 86 | 12.3 |
| 87 | 10.5 |
| 88 | 9.6 |
| 89 | 8 |
| 90 | 5.8 |
| 91 | 4.8 |
| 92 | 3 |
| 93 | 2 |
| 94 | 0 |

# APPENDIX 2

**Table showing the relationship between coolant temperature and of the radiator fan thermister resistance measured at that temperature. NB figures accurate at the time of publication.**

| Temperature Degrees C | Thermister Resistance (K ohms) | Test Box equivalent (K ohms) |
|---|---|---|
| 35 | 7.9 | |
| 40 | 6.6 | |
| 45 | 5.5 | |
| 50 | 4.6 | |
| 55 | 3.85 | |
| 60 | 3.25 | |
| 65 | 2.75 | |
| 70 | 2.33 | |
| 75 | 1.79 | |
| 80 | 1.7 | 2.1 |
| 85 | 1.45 | |
| 87<br>(rad fan cut in temp) | 1.36 | 1.7 |
| 90 | 1.24 | |
| 93<br>(max rad fan speed 2400/2800 rpm) | 1.13 | 1.37 |
| 95 | 1.07 | |
| 100 | 0.93 | 1.1 |

## Common Defects to Hydrostatic Systems

| Type of failure | Likelihood |
|---|---|
| Radiator fan solenoid seals leaking | High |
| Radiator fan solenoid defective | High |
| Alternator solenoid seals leaking | High |
| Alternator solenoid defective | High |
| Hydraulic oil coolers failing | Medium |
| Serck pump pipes loose/leaking | Medium |
| Drive coupling defective | Low |
| Serck control box | Low |

## Battery Problems

The way that we use and maintain the batteries (particularly the auxiliary battery) and the way we use battery chargers results in failure of battery cells much sooner than the manufacturers specified battery life expectancy for normal use. This is now being looked at and will probably result in modifications to vehicles (altering the load on the auxiliary battery) modifications to working practice and ammendments to maintenance specifications.